The Transparency Standard: Safety, Combustion Chemistry, and the Case for Botanical Terpene Enhancement in Commercial Cannabis

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June 2026
WORKING PAPER — NOT PEER-REVIEWED

> ***Disclosure:*** *This paper is authored by the Terps USA Scientific Board and reflects the company's research position on post-harvest botanical terpene enhancement. It is the second in a series of Terps USA Research publications. The first paper, "Botanical Terpene Spray Application in Cannabis Flower: A Practical Industry Guide to Aroma Restoration, Batch Consistency, and Post-Harvest Enhancement" (Fry, K., 2026), is available at https://doi.org/10.5281/zenodo.20511733 and provides the foundational application framework upon which this safety and transparency analysis builds.*

Abstract

The commercial cannabis industry is undergoing a structural shift. As of early 2026, pre-rolled joints and infused products have overtaken whole flower as the top-grossing product category in North America. This shift relies heavily on the utilization of bulk trim and lower-tier biomass, necessitating post-harvest flavor enhancement — primarily through the application of terpene sprays. However, the rapid adoption of this practice has outpaced consumer education and regulatory frameworks, leading to a rising controversy over "sprayed weed" and concerns regarding inhalation safety. This paper examines the combustion chemistry of botanical terpenes, the avoidable toxicant risks associated with carrier oils (PG/PEG) and aerosol propellants, and the economic drivers of the pre-roll market. It builds upon the application protocols and formulation standards established in the authors' prior publication on botanical terpene spray application [8]. We propose a "Transparency Standard" for the industry: affirming that post-harvest terpene enhancement is a necessary agricultural practice that can eliminate avoidable inhalation risk when executed with pure botanical compounds, mechanical atomization, and full consumer disclosure.

1. Introduction: The Pre-Roll Paradigm Shift

The economics of commercial cannabis cultivation have fundamentally changed. Wholesale flower prices have compressed significantly from their 2022 peaks, forcing cultivators and processors to maximize the yield and value of every gram of biomass.

By the first quarter of 2026, market data confirmed a historic milestone: pre-rolls surpassed whole flower as the top-selling cannabis product category by unit volume [1]. Infused pre-rolls generated over $1.68 billion in revenue in 2025, accounting for 47% of the entire pre-roll category [1].

This market reality dictates that commercial operators must utilize bulk trim, shake, and aging inventory to meet the demand for pre-rolled products. However, these materials inherently suffer from rapid terpene degradation due to increased surface area exposure to oxygen and light. To ensure batch-to-batch consistency, restore lost aroma, and meet consumer expectations for strain-specific flavor profiles, the industry has widely adopted post-harvest terpene enhancement (commonly referred to as “terpene spraying”).

Despite its ubiquity in the supply chain, terpene enhancement remains a stigmatized topic. The lack of industry transparency has fueled consumer skepticism, leading to the colloquial pejorative “sprayed weed.” This paper addresses the scientific realities behind these concerns and establishes a framework for safer, transparent enhancement.

2. The Chemistry of Botanical Terpenes vs. Cannabis-Derived Terpenes

The primary consumer objection to enhanced cannabis is the perception that it is “fake” or “synthetic.” This stems from a misunderstanding of terpene chemistry.

Terpenes are volatile organic aromatic hydrocarbons. A molecule of D-Limonene extracted from the rind of a citrus fruit is chemically and structurally identical to a molecule of D-Limonene synthesized in the glandular trichomes of a Cannabis sativa plant. The source of the extraction does not alter the molecular structure or its interaction with the human endocannabinoid system [2].

Commercial enhancement predominantly utilizes botanical-derived terpenes rather than cannabis-derived terpenes for three critical reasons:

- **Scalability:** Botanical terpenes can be sourced in commercial volumes necessary for large-scale manufacturing. The formulation principles and sourcing standards for commercial-grade botanical terpenes are detailed in the authors’ prior publication [8].
- **Consistency:** Botanical formulations allow for precise, repeatable ratios, ensuring that a specific flavor profile remains identical across multiple harvests and product runs.
- **Purity Profiling:** Many common botanical terpenes possess well-characterized chemical structures and extensive toxicological data compared

with complex whole-plant extracts, which often contain trace amounts of unknown minor compounds, waxes, and lipids that can introduce unpredictable variables during combustion.

3. Combustion Safety: Separating Terpenes from Carrier Oils and Propellants

The skepticism surrounding inhaled enhancements is deeply rooted in the 2019 EVALI (E-cigarette or Vaping Use-Associated Lung Injury) crisis. While the CDC conclusively linked the vast majority of EVALI cases to Vitamin E acetate used as a cutting agent in illicit THC vape cartridges [3], the crisis rightfully heightened scrutiny regarding all inhalable additives.

When evaluating the safety of terpene sprays applied to combustible flower, the scientific focus must be on pyrolysis and combustion chemistry, distinctly separating pure terpenes from the diluents and propellants commonly used to apply them.

The Danger of Carrier Oils (PG and PEG)

Historically, many cheap flavor sprays and vape liquids utilized Propylene Glycol (PG) or Polyethylene Glycol (PEG) as carrier oils to dilute the terpenes and reduce manufacturing costs. While PG and PEG are Generally Recognized As Safe (GRAS) by the FDA for ingestion and topical use, they present severe, documented risks when subjected to the high temperatures of combustion.

Research has repeatedly demonstrated that at high temperatures, PG and PEG undergo thermal degradation, producing highly toxic carbonyl compounds, including formaldehyde and acetaldehyde [4][5]. Therefore, any terpene formulation applied to combustible cannabis flower must be 100% PG-free, PEG-free, and MCT-free to avoid the generation of these specific severe toxicants.

The Danger of Aerosol Propellants

A secondary, yet equally critical, safety concern is the method of application. Some commercial terpene sprays are packaged in pressurized aerosol cans. These systems rely on chemical propellants (often butane, isobutane, or propane derivatives) to force the liquid out of the canister. Spraying chemical propellants directly onto consumable flower introduces non-terpene hydrocarbons into the biomass, posing both a compliance risk for residual solvent testing and an unnecessary inhalation risk to the consumer.

The Reality of Terpene Pyrolysis

It is critical to state plainly that the combustion of any organic material — including pure botanical terpenes and the terpenes naturally occurring in unenhanced cannabis flower — generates degradation products. Studies evaluating the high-

temperature dabbing and vaporization of pure terpenes (such as myrcene, limonene, and linalool) have identified the formation of toxicologically relevant degradation products, including methacrolein and, at the highest temperatures tested, benzene [6][7].

This is not a risk unique to enhanced flower. Because the terpenes used in botanical enhancement are molecularly identical to the terpenes the plant already produces, combusting enhanced flower does not introduce a new category of degradation chemistry — it produces the same class of byproducts that combustion of any cannabis flower, enhanced or not, already generates. The relevant distinction is therefore not between enhanced and unenhanced flower, but between two categories of inhalation risk: risk that is intrinsic to combusting cannabis terpenes at all, and risk that is entirely avoidable through formulation choice. PG/PEG carrier oils and aerosol propellants fall into the second category — they introduce toxicant pathways (formaldehyde, acetaldehyde, residual hydrocarbons) that have no natural counterpart in cannabis combustion and exist solely because of how the product was diluted or packaged [4][5].

Two open questions deserve explicit acknowledgment rather than assumption. First, dose: because enhancement is intended to restore terpene content lost during drying, curing, and handling, enhanced flower may carry a higher total terpene mass at the point of combustion than the same flower would carry naturally at that stage of degradation. Identical chemistry per molecule does not guarantee identical total degradation-product yield per gram smoked, and this has not yet been directly quantified. Second, temperature: the cited terpene pyrolysis studies were conducted under dabbing and vaporization conditions reaching approximately 526°C. A lit cannabis cigarette can reach combustion temperatures at or above this range, and pyrolysis chemistry generally produces more, not fewer, degradation products as temperature increases. The available data should therefore be read as a lower-bound characterization of the relevant chemistry, not a direct measurement of joint-combustion conditions.

Safe post-harvest enhancement requires eliminating every avoidable risk, even as the intrinsic risk of combusting any cannabis terpene is acknowledged rather than denied. This is achieved through two non-negotiable standards:

- **Pure Formulation:** The use of 100% pure, undiluted botanical terpenes without PG, PEG, MCT, or Vitamin E acetate.
- **Mechanical Atomization:** The use of air-pressurized atomization systems (such as the Terps USA Spray Master) that utilize mechanical air pressure to create a micro-mist, completely eliminating the need for chemical aerosol propellants.

4. The Call for Industry Transparency

The current paradigm — where cultivators enhance flower to survive economically, but hide the practice from dispensaries and consumers — is unsustainable. It breeds distrust and allows bad actors using unsafe, uncalibrated aerosol sprays to operate in the shadows.

We propose The Transparency Standard:

- **Disclosure:** Brands and dispensaries should proudly label enhanced products as “Botanically Enhanced” or “Infused with Botanical Terpenes.”
- **Education:** Consumers must be educated that botanical enhancement is a standardized agricultural practice designed to ensure consistency and quality, akin to flavor engineering in the food and beverage sectors.
- **Safety Verification:** Cultivators must demand Certificates of Analysis (COAs) from terpene suppliers proving the absence of PG, PEG, MCT, and Vitamin E acetate, and reject the use of aerosol propellant delivery systems.

When a consumer purchases an infused pre-roll or a bag of enhanced flower, they are seeking a specific, reliable sensory experience. Transparency does not diminish the value of the product; it validates it. By disclosing the use of pure botanical terpenes, the industry can transition from defensive posturing to proactive quality assurance.

5. Limitations and Future Research

While the avoidable-risk framework outlined in Section 3 distinguishes carrier-oil and propellant toxicants from the intrinsic byproducts of terpene combustion, inhalation toxicology in this area remains an evolving field, and two specific gaps warrant direct study rather than inference.

The first is dose-equivalence: no published study to date has directly measured and compared total degradation-product yield (per gram combusted) between enhanced and unenhanced flower under matched smoking conditions. Until that comparison exists, claims about relative exposure should be treated as a reasoned hypothesis rather than an established finding.

The second is temperature-transferability: the terpene pyrolysis literature cited in this paper derives from dabbing and vaporization studies, not from direct combustion of rolled flower. Research specifically characterizing terpene degradation products under real-world joint-combustion conditions — including peak cherry temperature and puff topography — would substantially strengthen or revise the conclusions presented here.

Further peer-reviewed research addressing both gaps is warranted to fully quantify the toxicological impact of botanical terpene enhancement relative to unenhanced flower.

6. Conclusion

The explosive growth of the pre-roll market and the economic realities of commercial cultivation have made post-harvest terpene enhancement a permanent fixture in the cannabis supply chain. The controversy surrounding “sprayed weed” is not an indictment of terpenes themselves, but a symptom of industry opacity and the lingering trauma of the EVALI crisis.

By adhering to strict combustion safety standards — utilizing only pure botanical terpenes and mechanical, propellant-free atomization — commercial operators can restore aroma and ensure batch consistency while eliminating the specific, avoidable toxicant risks associated with carrier oils, propellants, and adulterants. The intrinsic chemistry of combusting cannabis terpenes is a separate, ongoing area of research that applies to all flower, enhanced or not, and should be characterized honestly rather than minimized. It is time for the cannabis industry to adopt the Transparency Standard, replacing secrecy with science, and providing consumers with consistent, fully disclosed, and honestly characterized products.

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